Status of the CERES Surface-Only Flux Algorithms for Edition 4

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Background (Page 1)

CERES uses several surface-only flux algorithms to compute SW and LW surface fluxes in conjunction with the detailed model used by SARB. These algorithms include:

LPSA/LPLA:
Langley Parameterized SW/LW Algorithm

		Model A	Model B	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

References:

SW A: Li et al. (1993): *J. Climate*, **6**, 1764-1772.

SW B: Darnell et al. (1992): *J Geophys. Res*., **97**, 15741-15760.

Gupta et al. (2001): *NASA/TP-2001-211272*, 31 pp.

LW A: Inamdar and Ramanathan (1997): *Tellus,* **49B**, 216-230.

LW B: Gupta et al. (1992): *J. Appl. Meteor.,* **31**, 1361-1367.

LW C: Zhou et al. (2007): *J. Geophys. Res*., **112**, D15102.

SOFA: Kratz et al. (2010): *J. Appl. Meteor. Climatol*., **49**, 164-180.

SOFA: Gupta et al. (2010): *J. Appl. Meteor. Climatol.,* **49**, 1579-1589.

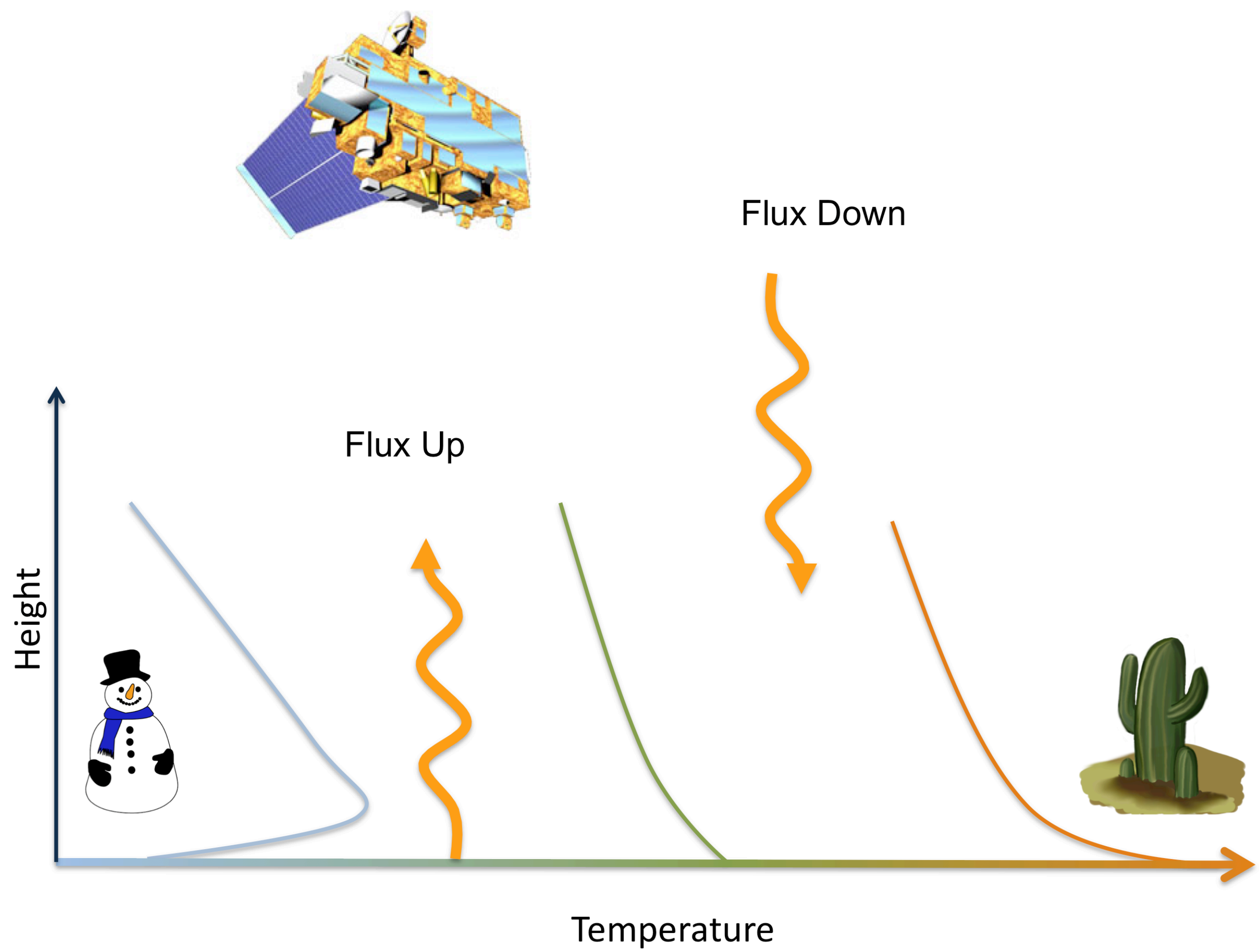
Background (Page 2)

- The SOFA LW & SW Models are based on rapid, highly parameterized TOA-to-surface transfer algorithms to derive surface fluxes.
- LW Models A & B as well as SW Model A were incorporated at the start of the CERES project.
- SW Model B was adapted for use in the CERES processing shortly before the launch of TRMM.
- The Edition 2B LW & SW surface flux results underwent extensive validation (See: Kratz et al. 2010), and can be used to provide independent verification of the SARB results.
- The ongoing validation process has already led to improvements to the LW models (Gupta et al., 2010).
- LW Model C will be introduced in Edition 4 processing to maintain two independent LW algorithms after the CERES Window Channel is replaced in future versions of the CERES instrument.

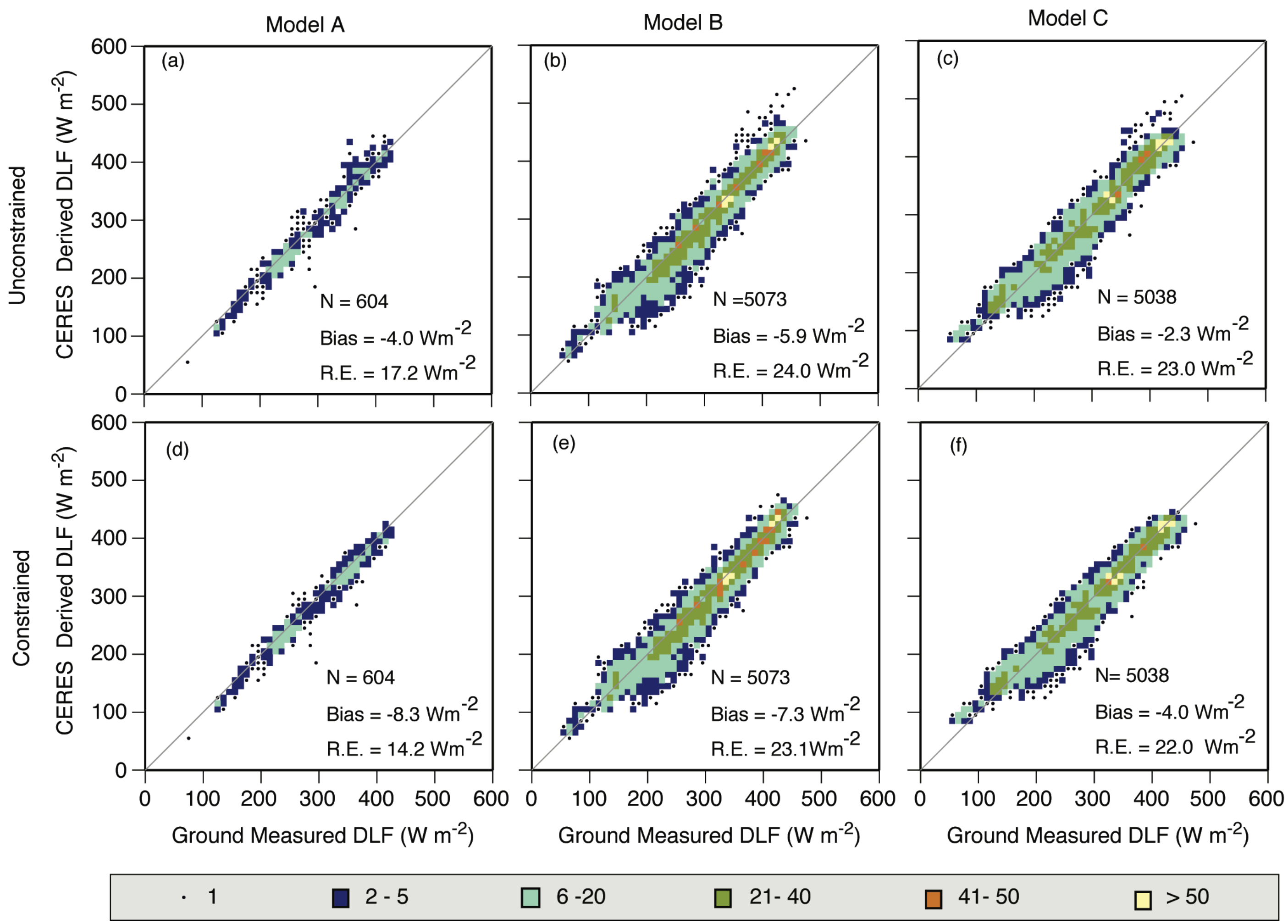
Status of LW Models as of January 2010

- Validation of LW Models A & B reported by Kratz et al. (2010).
- LW Model A provides very good clear-sky results for most validation sites; however, the polar sites yield a modest negative bias due to a known discrepancy at low water vapor amounts.
- LW Models B & C provide very good clear-sky and all-sky results for all of the validation sites that have been considered.
- LW Models A, B & C tend to overestimate downward surface fluxes for conditions where the surface temperatures significantly exceed the lowest layer air temperature, and underestimate downward surface fluxes for conditions where inversions exist.

Temperature Profiles for Various Conditions



Results of applying the high T_s constraint in the LW Models [Maximum lapse rate in the lowest layer = 10K/100hPa]



Gupta et al (2010)

January & July 2004

Monthly mean (solid line) atmospheric temperature profiles from 2 m above surface to 30 km above MSL over the South Pole (The dashed lines show the 10th and 90th percentiles of temperature at each height). Figure adopted from Hudson and Brandt (2005), *J. Climate*, **18**, 1673-1696.

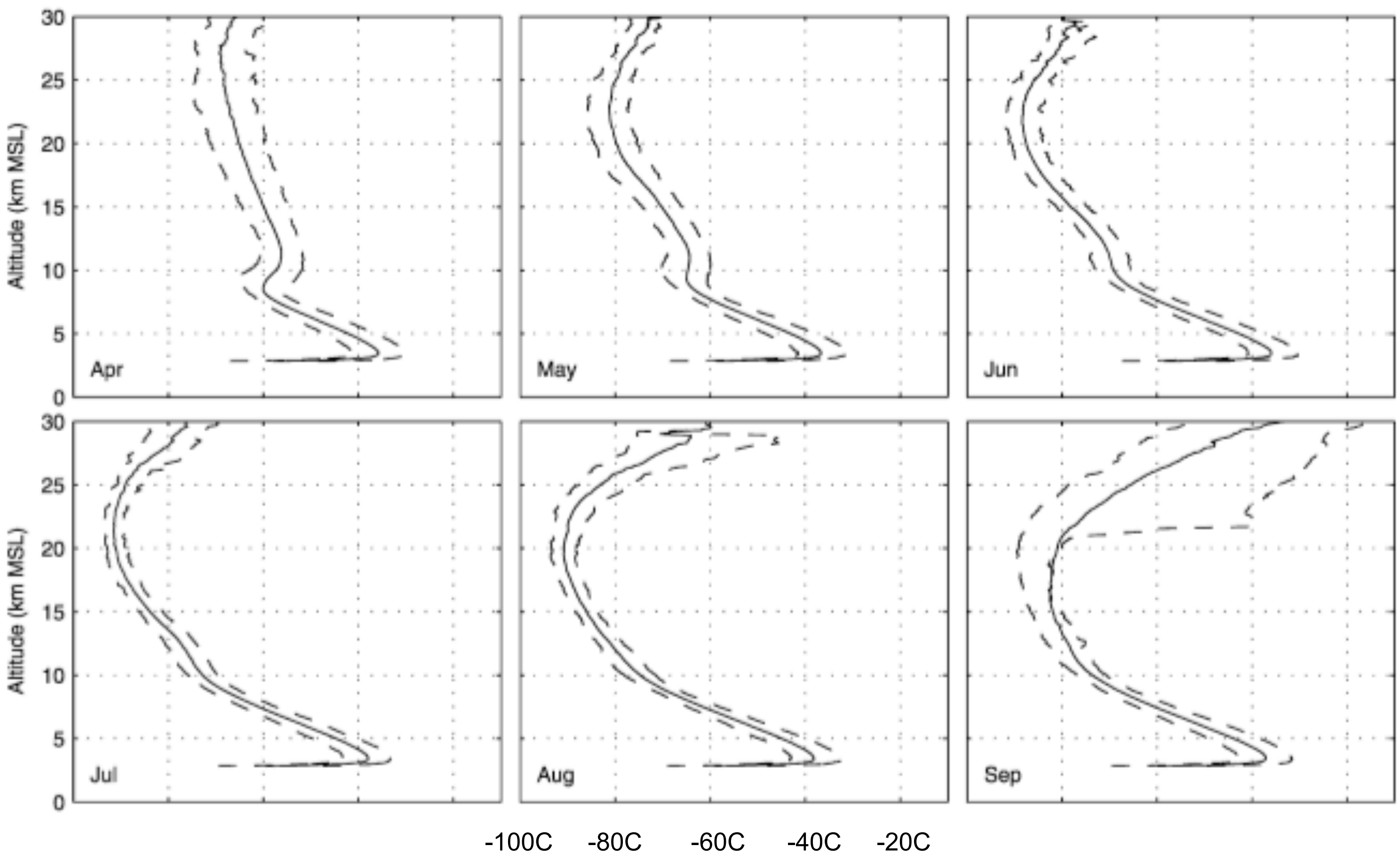


Chart of recent test cases run to improve the accuracy of the LW Models

Designation	High Temp Constraint	Inversion T_{con} Value (Range 1)	Inversion T_{con} Value (Range 2)	Inversion T_{con} Value (Range 3)	Notes on Inversions
T_{geos} (Ed T2G)					1
Ts	10K in L1				2
Ts0	10K in L1	0K (<0K)			3
Ts0a (Ed 3A)	10K in L1	0K or no limit (<0K)			4
Ts41	10K in L1	0K (0K to –10K)	–10K (–10K to –20K)	–20K (<–20K)	5
Ts42	10K in L1	0K (0K to –10K)	–10K (<–10K)		6
Ts43 (Ed 4)	10K in L1	–xK (0K to –10K)	–10K (<–10K)		7

Note 1: Surface temperature is provided through GEOS 5.2.0 for Editions Terra 2G and Aqua 2D

Note 2-7: The high surface temperature constraint of 10K within the first layer (L1) is applied to all of the following calculations, which use GEOS 5.2.0 as the base case.

Note 2: All inversions are allowed (No inversion correction applied).

Note 3: No inversions are allowed.

Note 4: No inversions are allowed except at the poles where inversions are not limited.

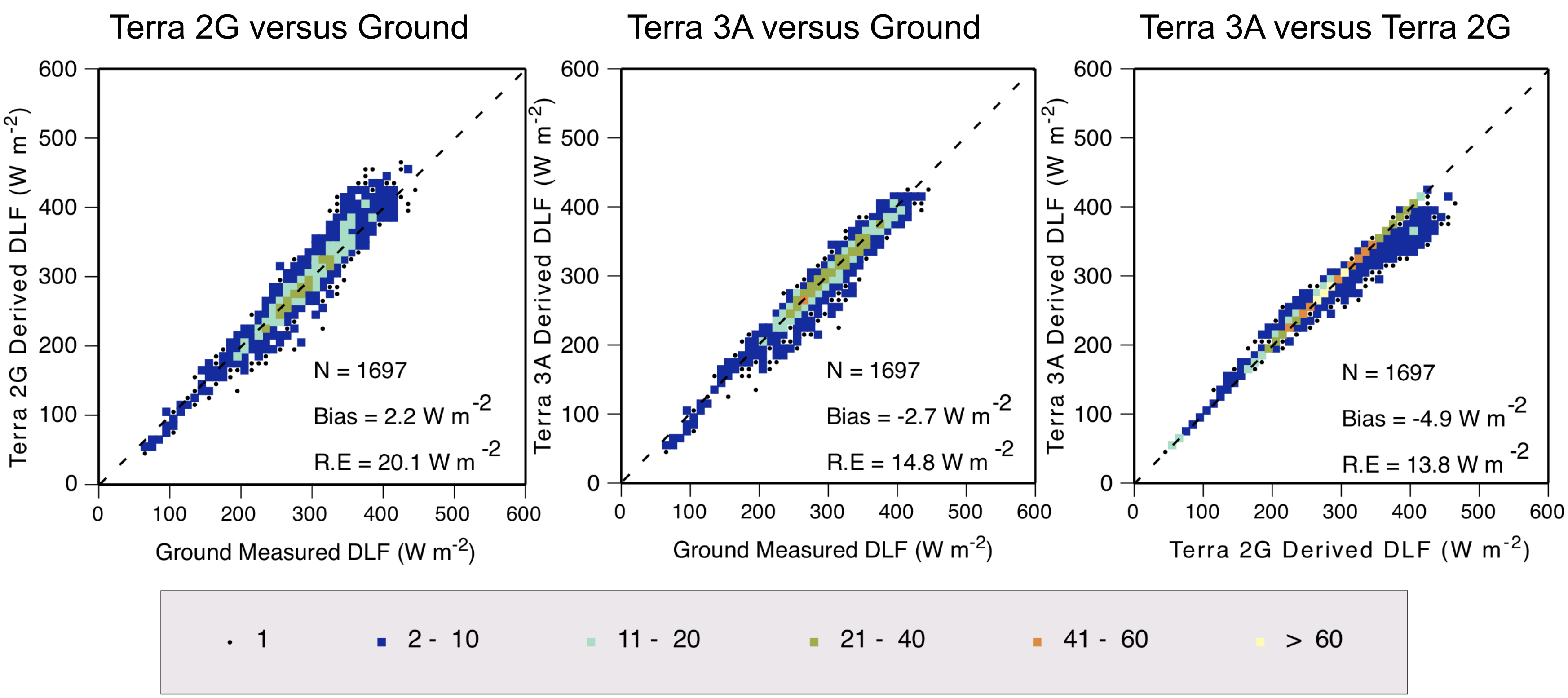
Note 5: Inversions from 0K to –10K are reset to 0K, inversions from –10K to –20K are reset to –10K, and inversions beyond –20K are reset to –20K.

Note 6: Inversions from 0K to –10K are reset to 0K, and inversions beyond –10K are reset to –10K.

Note 7: Inversions from 0K to –10K keep their initial value, and inversions beyond –10K are reset to –10K.

Comparison between CERES Terra Editions 2G and 3A for 2008

LW Model A code changes between Editions 2G to 3A include:
1) A constraint method to prevent super-adiabatic lapse rates and
2) A constraint method to prevent inversions except for polar regions and high altitude cases.

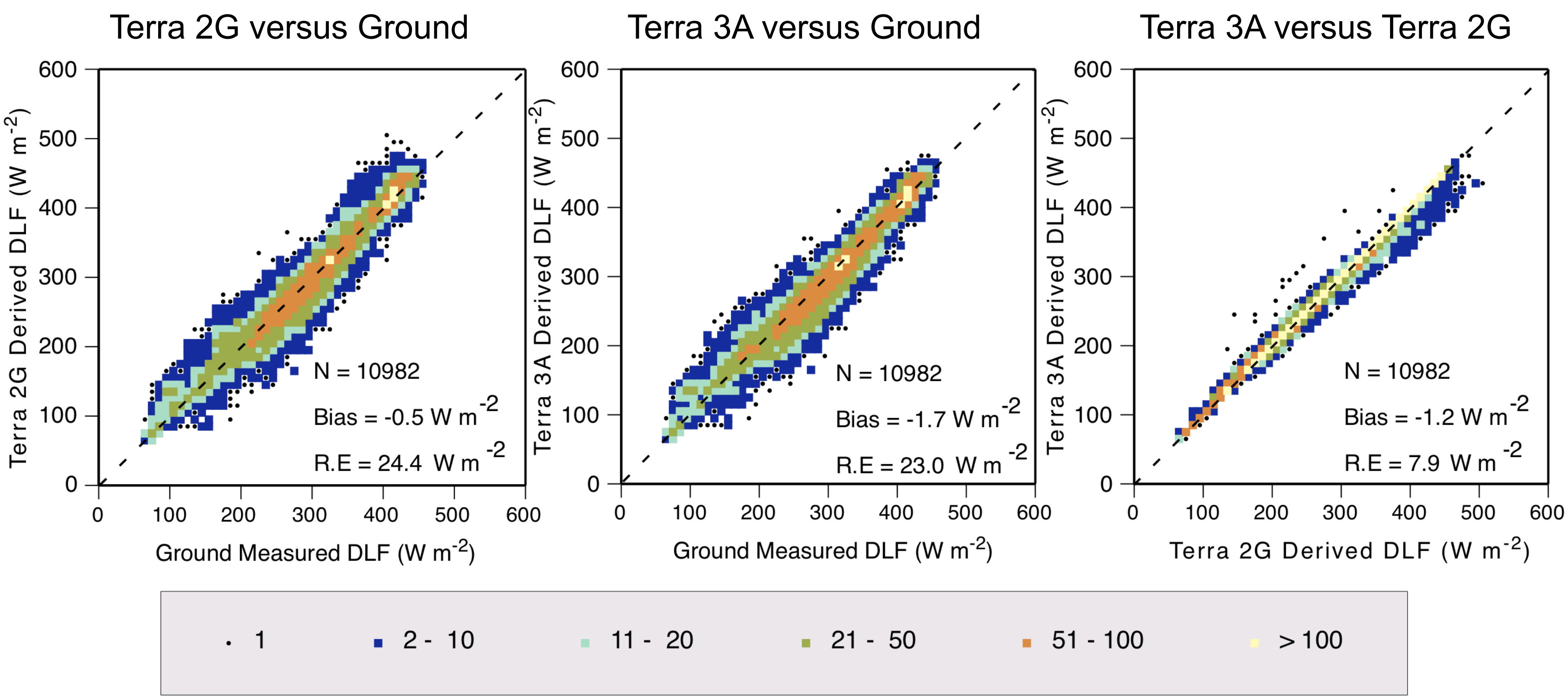


Case 4 versus Case 1

Comparison between CERES Terra Editions 2G and 3A for 2008

LW Model B code changes between Editions 2G to 3A include:

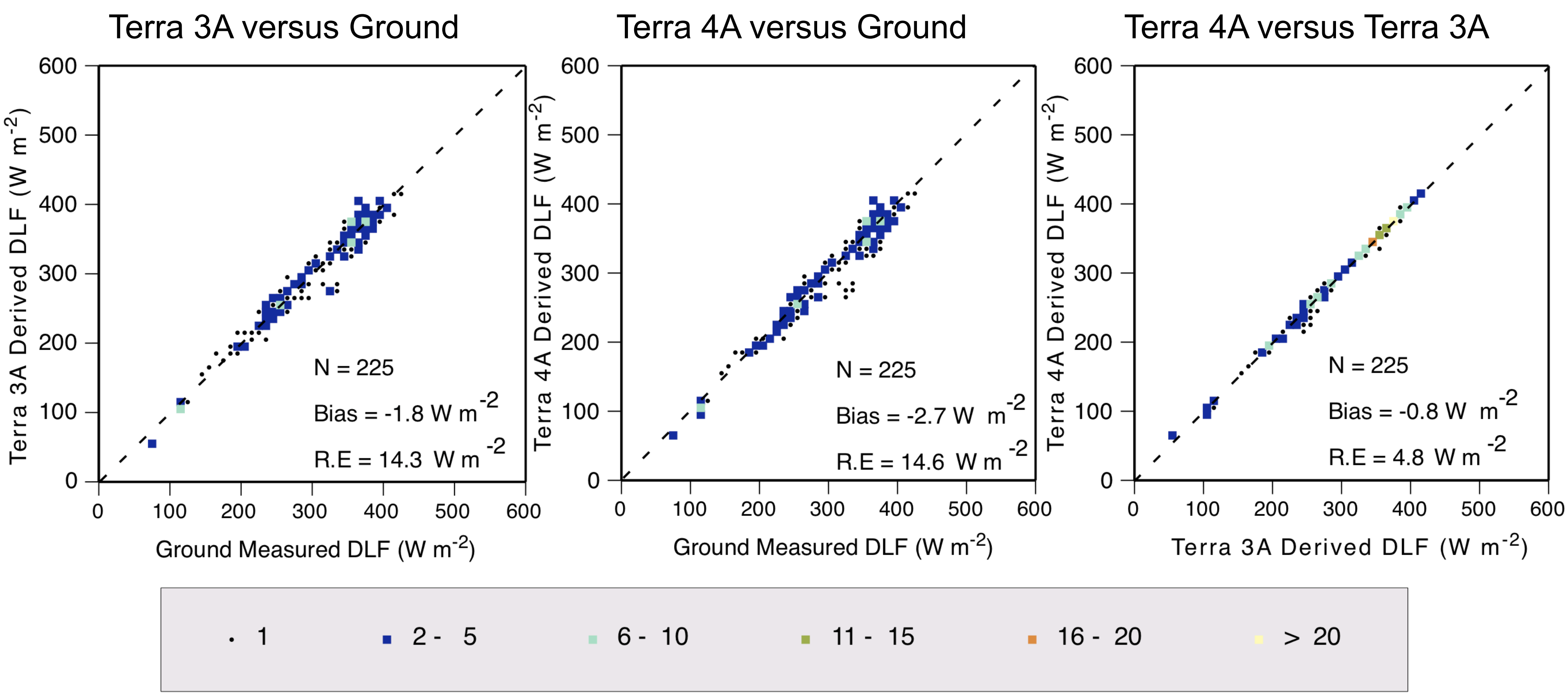
1) A constraint method to prevent super-adiabatic lapse rates and
2) A constraint method to prevent inversions except for polar regions and high altitude cases.



Case 4 versus Case 1

Comparison between CERES Terra Editions 2G and 3A for 2008

LW Model A code changes between Editions 2G to 3A include:
1) A constraint method to limit inversions of 10K
rather than a constraint method to prevent inversions
except for polar regions and high altitude cases.



January & July 2008

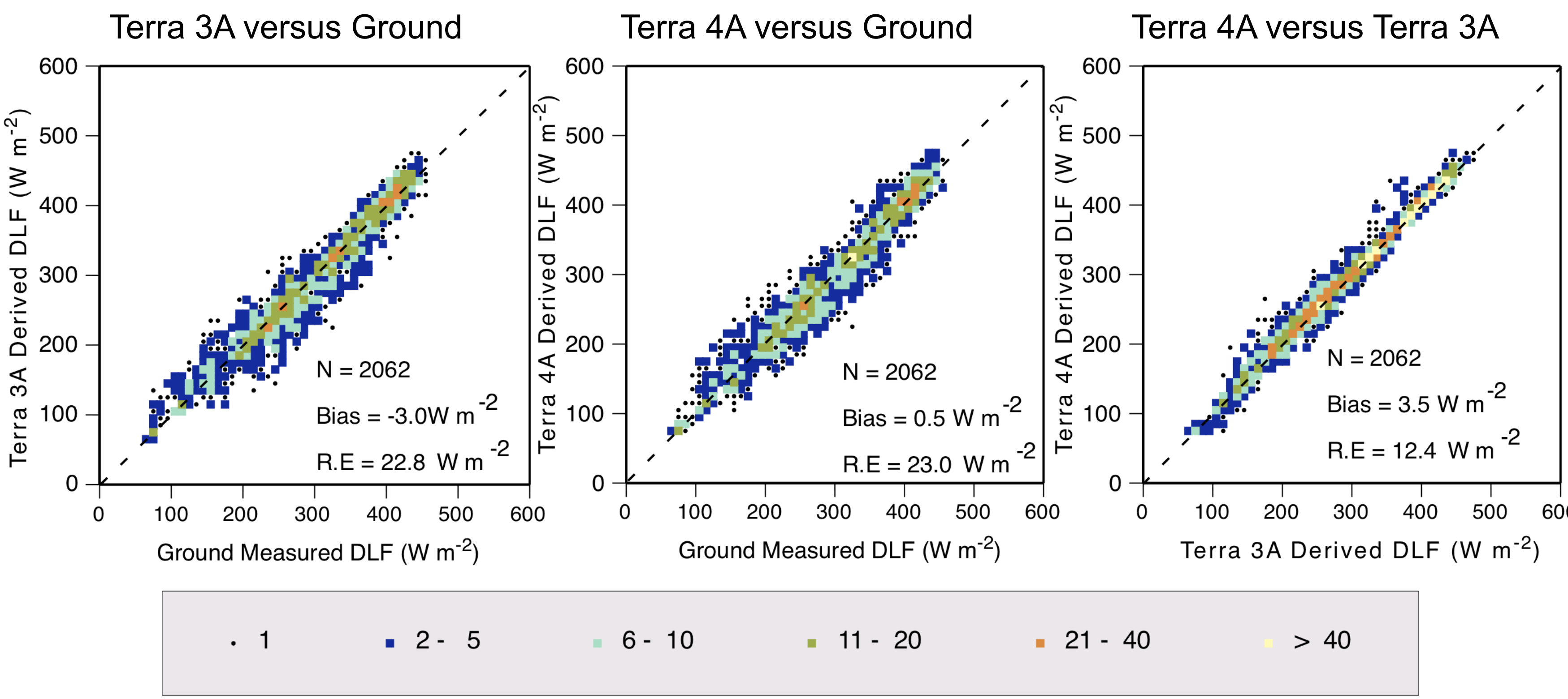
Case 7 versus Case 4

Climate Science Branch, NASA Langley Research Center

Comparison between CERES Terra Editions 3A and 4A for 2008

LW Model B code changes between Editions 3A to 4A include:

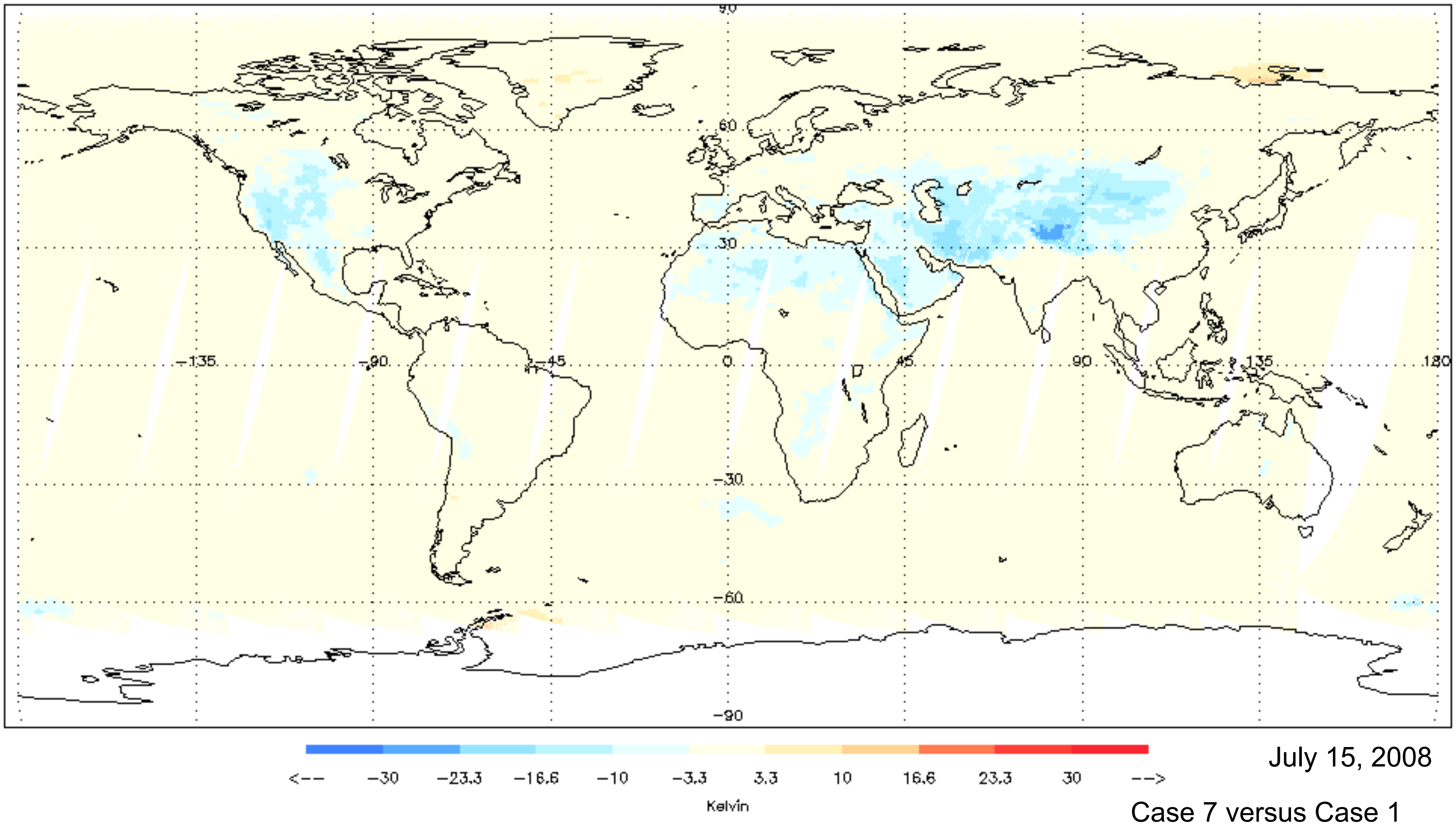
1) A constraint method to limit inversions to 10K
rather than a constraint method to prevent inversions
except for polar regions and high altitude cases.



January & July 2008

Case 7 versus Case 4

Near-surface temperature (day) differences between 1) retrievals with constraints that prevent super-adiabatic lapse rates and inversions greater than 10K, and 2) retrievals with no constraints

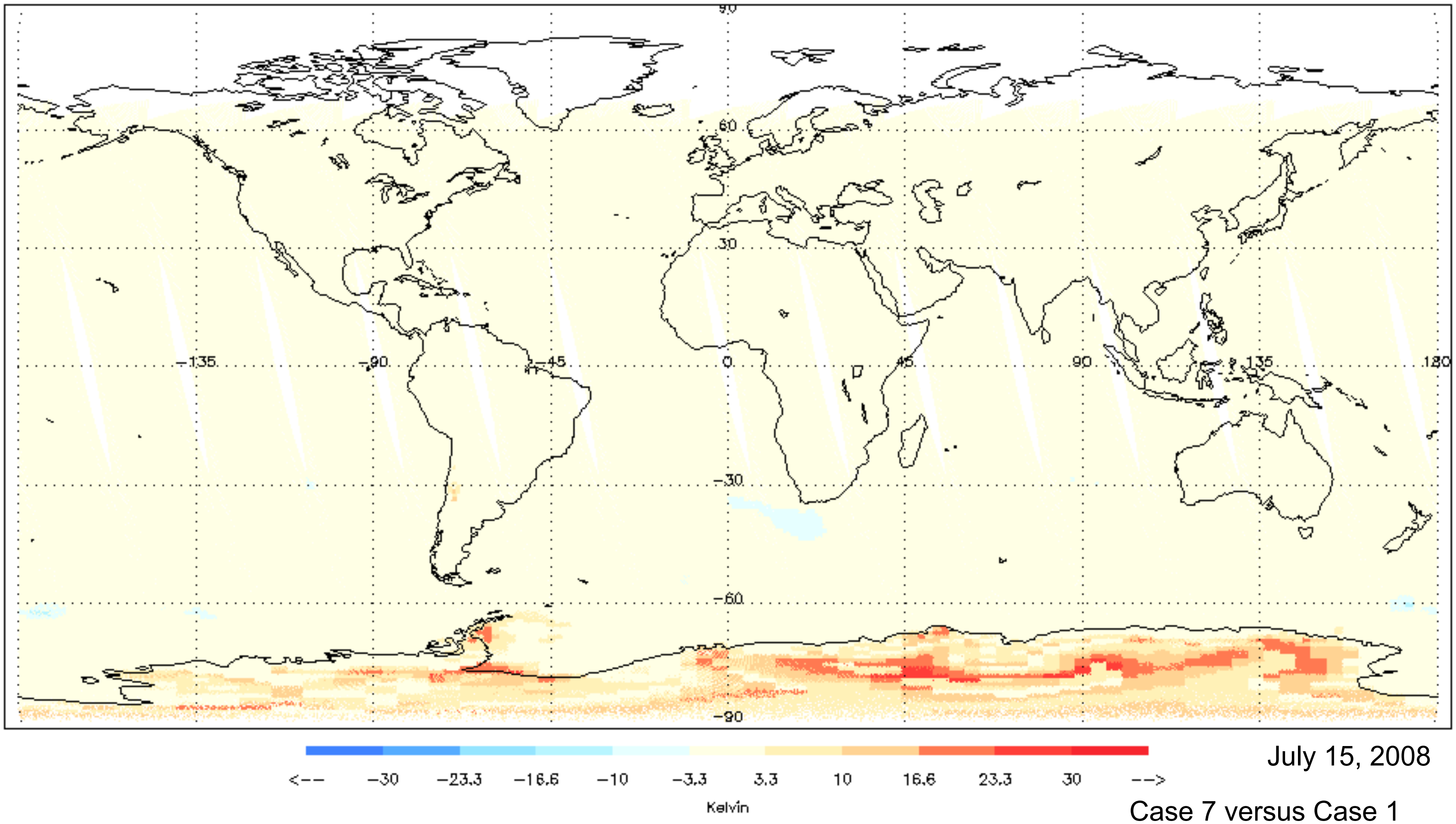


July 15, 2008

Case 7 versus Case 1

Climate Science Branch, NASA Langley Research Center

Near-surface temperature (night) differences between 1) retrievals with constraints that prevent super-adiabatic lapse rates and inversions greater than 10K, and 2) retrievals with no constraints



July 15, 2008

Case 7 versus Case 1

Climate Science Branch, NASA Langley Research Center

Results of Recent LW Model Improvements

To improve upon the accuracy of the LW Models, methods have been formulated to constrain the near-surface air temperature for the downward flux calculations to allow for the effective management of two extreme conditions in LW Models A, B & C:

1) For the condition involving surface temperatures that greatly exceed the overlying air temperatures, constraining the lapse rate to 10 K/100 hPA (roughly the dry adiabatic lapse rate) has significantly improved the results, see Gupta et al. (2010).

2) For conditions involving surface temperatures that are much below the overlying air temperatures (strong inversions), limiting the inversion to a maximum of 10 K/100 hPa for the downward flux calculations provides the best results for all conditions, including the high altitude, low water vapor cases seen during the winter at the Antarctic Plateau. For these cases, the air temperatures immediately above the surface are not representative of the atmospheric emission to the surface.

Status of SW Models as of January 2010

- Validation of SW Models A & B reported by Kratz et al. (2010).

- SW Model A provides satisfactory global flux retrievals, though there remain problems with cloud contamination and significant flux underestimations for conditions with low water vapor amounts.

- SW Model B has been improved significantly, yielding very good results for clear through partly cloudy conditions; however, mostly cloudy to overcast conditions still yield a high bias.

SW Model B Algorithm Improvements for Edition 4 and beyond

- Replace the WCP-55 aerosol properties in SW Model B with the MATCH aerosol optical depths and the OPAC single scattering albedos and asymmetry parameters. ✔

- Revise the Rayleigh scattering formulation in SW Model B (See Bodhaine et al. (1999): *J. Atmos. Oceanic Tech*., **16**, 1854-1861). ✔

- Examine the relationship between clear and cloudy-sky results.

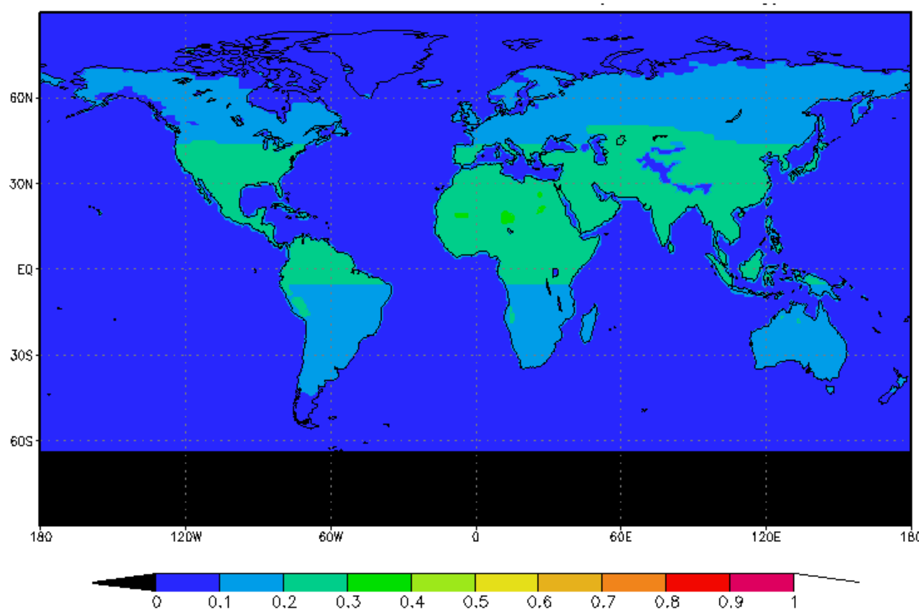
- Incorporate daily aerosol properties into SW Model B to account for the short term variability of aerosol properties.

Comparison of WCP-55 and MATCH Aerosol Optical Depths

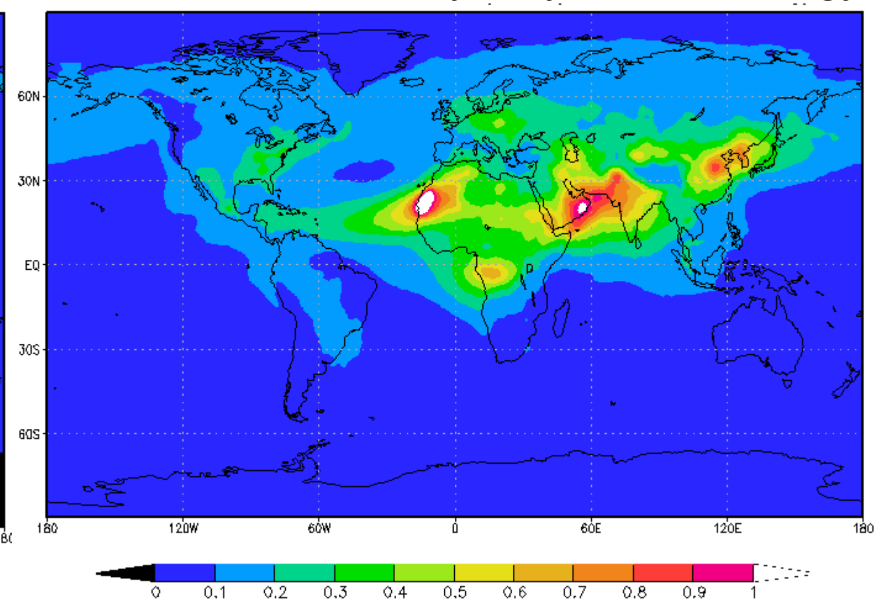
The MATCH aerosols provide a more realistic distribution of aerosol optical depths than the WCP-55 aerosols

Note: Also use OPAC single scattering albedos and asymmetry parameters

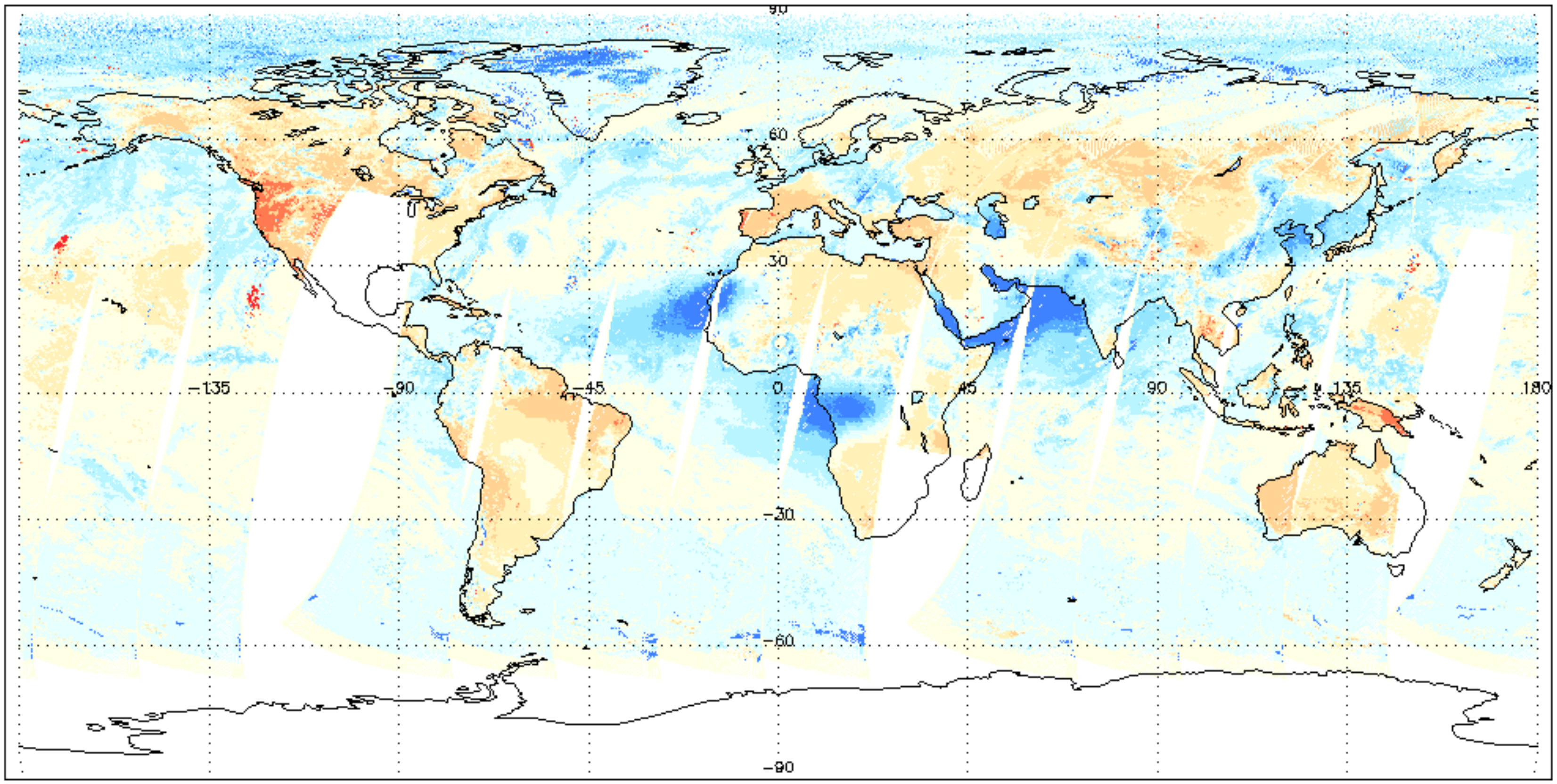
WCP-55 Broadband AOD July Climatology

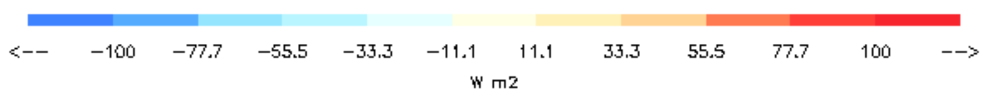


MATCH BB AOD July 10-year Climatology



Downward all-sky SW flux differences between SW Model B derivations using the new Rayleigh formula with MATCH aerosols and the original Rayleigh formula with WCP-55 aerosols





Edition 4 Beta

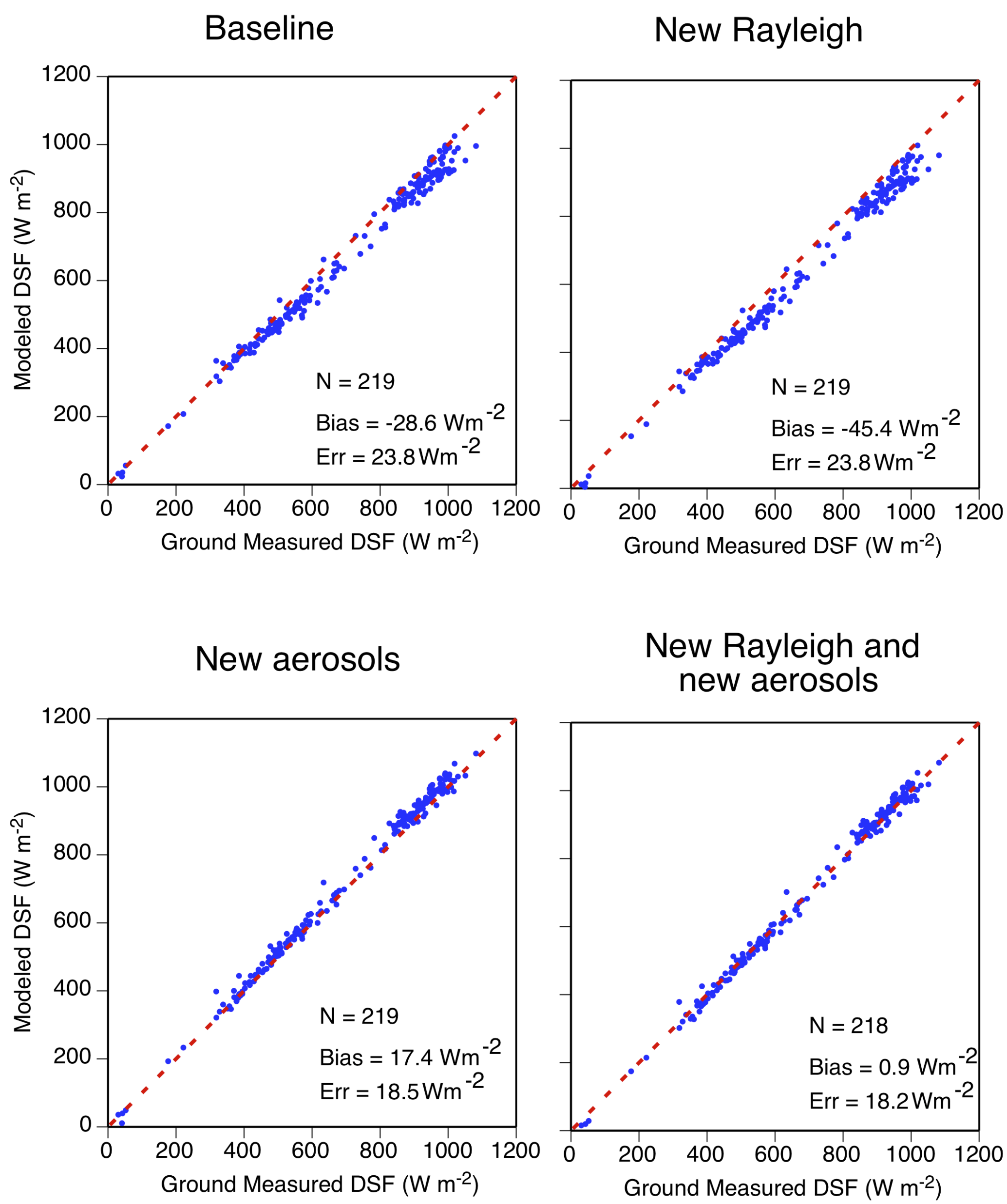
July 15, 2008

Comparison between surface-measured and CERES-derived fluxes: Clear-Sky

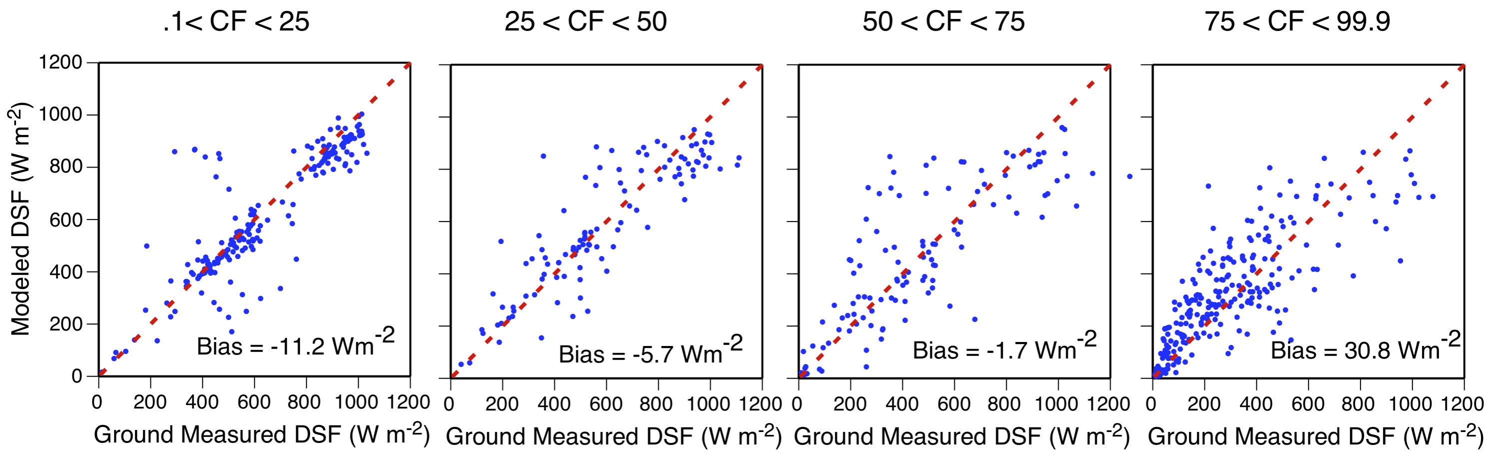
Clear-sky results for comparisons among the results for a) WCP-55 aerosols & old Rayleigh algorithm, b) WCP-55 aerosols & new Rayleigh algorithm, c) MATCH aerosols & old Rayleigh algorithm, and d) MATCH aerosols & new Rayleigh algorithm.

For the clear-sky case, the new formulation with the MATCH aerosols & the new Rayleigh algorithm shows a remarkable improvement.

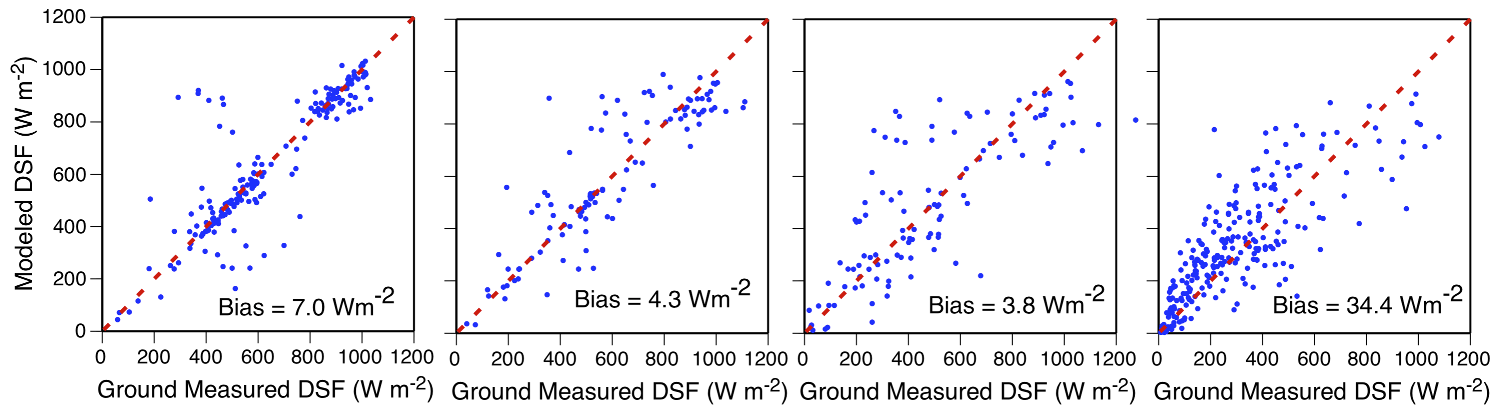
January & July 2004 results



Baseline



New Rayleigh and New Aerosols



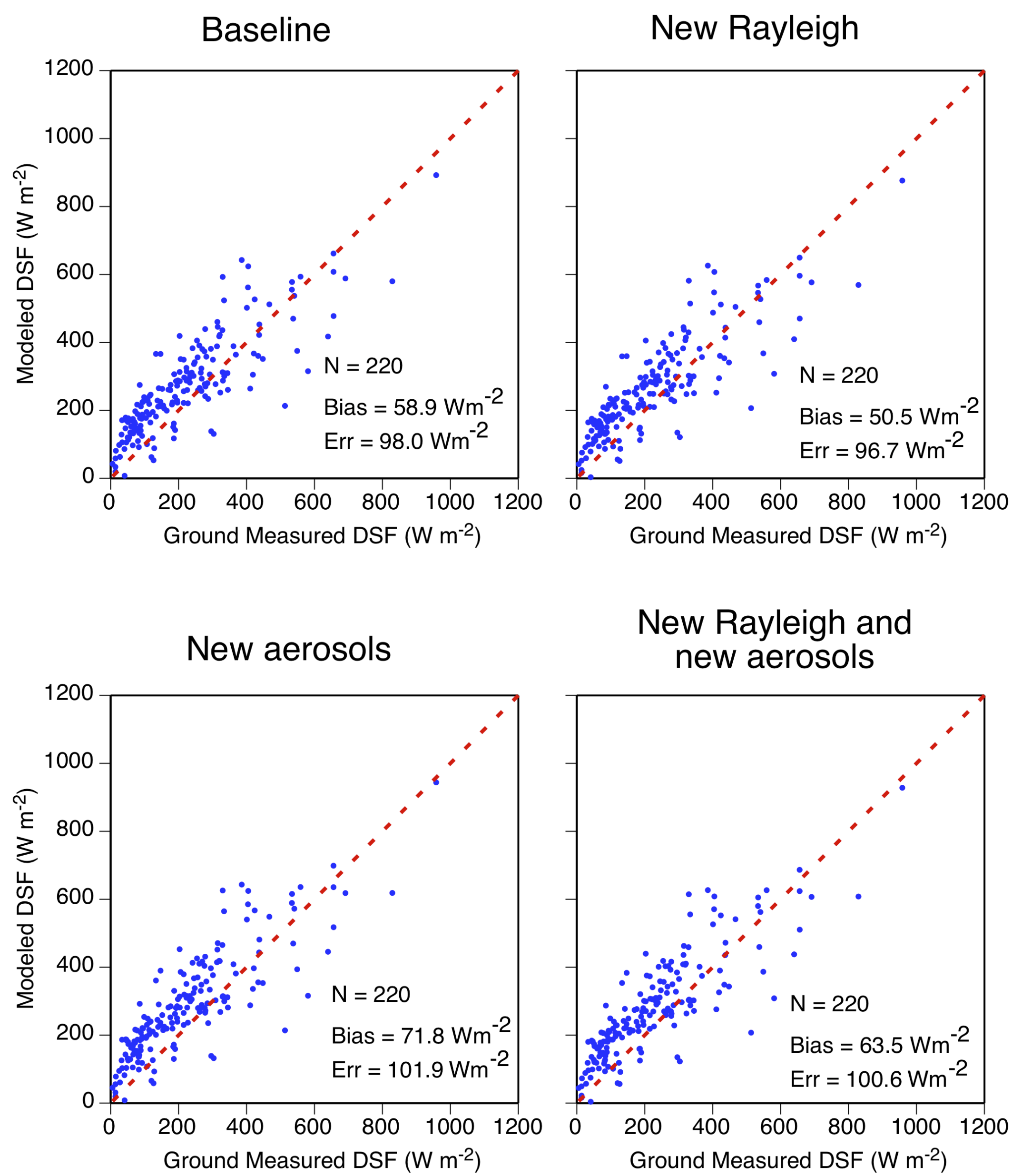
January & July 2004 results

Comparison between surface-measured and CERES-derived fluxes: Overcast

Overcast (> 99.9% cloudy) sky results for comparisons among the results for a) WCP-55 aerosols & old Rayleigh algorithm, b) WCP-55 aerosols & new Rayleigh algorithm, c) MATCH aerosols & old Rayleigh algorithm, and d) MATCH aerosols & new Rayleigh algorithm.

For the overcast (> 99.9% cloudy) sky case, the new formulation with the MATCH aerosols & the new Rayleigh algorithm shows no improvement.

January & July 2004 results



Results of Recent SW Model Improvements and Course of Action for the Future

Simultaneously replacing the original WCP-55 aerosols with the MATCH aerosols, and the original Rayleigh molecular scattering formulation with an improved Rayleigh molecular scattering formulation has significantly improved the surface SW flux calculations for clear through partly cloudy sky conditions.

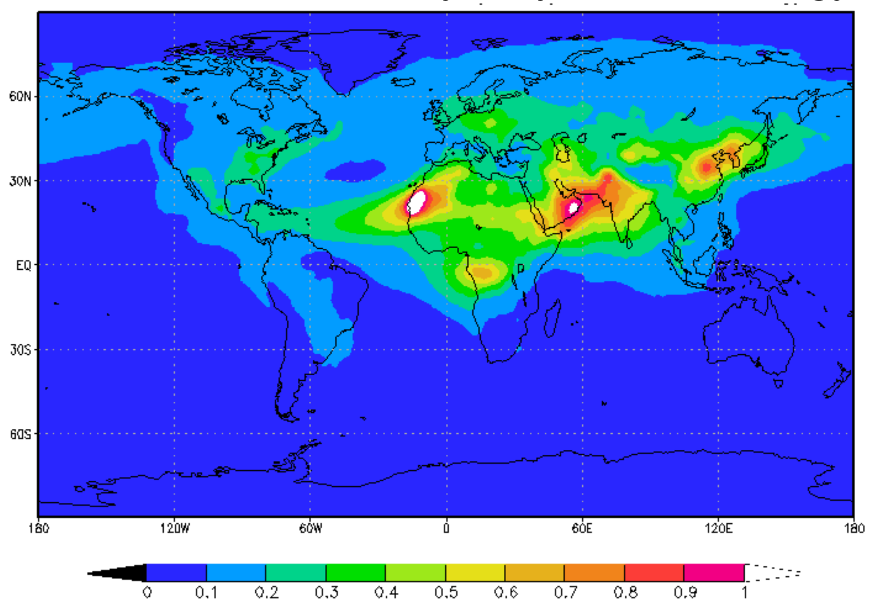
Results for the mostly cloudy to overcast conditions strongly suggest that further work on the cloud transmittance calculation is necessary. Our attention is currently focused on the formulae used for the cloud transmittance and the overcast albedo.

To account for the short term variability of aerosol properties, we plan to examine the feasibility of incorporating the daily aerosol properties into SW Model B.

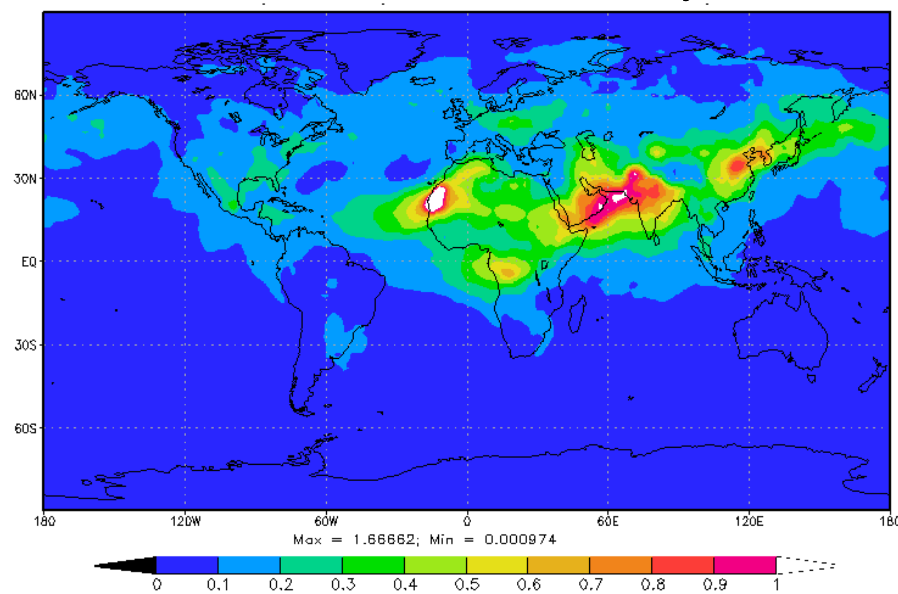
Comparison of MATCH Aerosol Optical Depths from Monthly Climatology to an Individual Month

The plot of the 10-year Climatology is representative of an individual month within that 10-year period.

MATCH BB AOD July 10-year Climatology



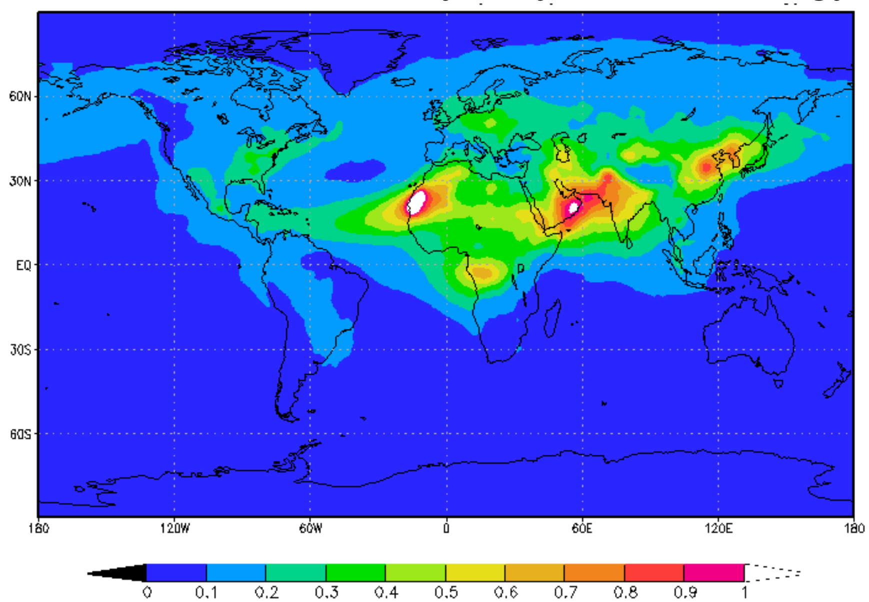
MATCH Broadband AOD July 2008



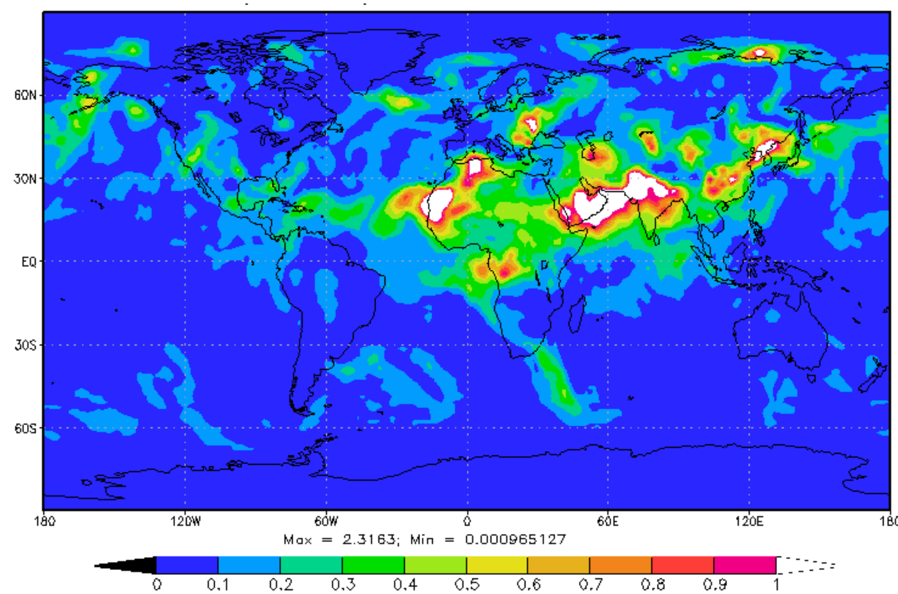
Comparison of MATCH Aerosol Optical Depths from Monthly Climatology to an Individual Day

The use of daily aerosol optical depths should allow for more precise retrievals, especially during periods with atypical aerosol loadings. In this plot an individual day of MATCH data is used to represent MODIS-derived broadband data.

MATCH BB AOD July 10-year Climatology



MATCH Broadband AOD 7/15/2008



CERES 2B/(T2D,A2G)/3A/4A and FLASHFlux 2G

Dataset	CERES 2B	CERES 2D/2G	CERES 3A	CERES Terra 4A	FLASHFlux 2G
GEOS Version	4.0.3	5.2.0	5.2.0	5.2.0	5.2.0
MODIS Collection	4	5	5	5	5
Spectral Corr. Coef.	CERES 2B	CERES 2D/2G	CERES 3A	CERES 3A	FLASH Version 4
Ozone Cutoff	500 DU	None	None	None	None
Clear-Sky TOA albedo Terra	48 month ERBE	48 month ERBE	70 month Terra	70 month Terra	70 month Terra
Clear-Sky TOA albedo Aqua	46 month Terra	46 month Terra	70 month Terra	70 month Terra	70 month Terra
Clear-Sky Surface albedo	46 month Terra	46 month Terra	70 month Terra	70 month Terra	70 month Terra
TOA to surface albedo transfer	Instantaneous	Instantaneous	Monthly average	Monthly average	Monthly average
Clouds Algorithm Terra	Terra Ed2	Terra Ed2	Terra Ed2	Terra/Aqua Ed4	Modified Terra Ed2
Cloud Algorithm Aqua	Aqua Ed1	Aqua Ed1	Aqua Ed1	Terra/Aqua Ed4	Modified Terra Ed2
SW aerosol dataset	WCP-55	WCP-55	WCP-55	MATCH/OPAC	WCP-55
Rayleigh Treatment	LPSA	LPSA	LPSA	Bodhaine et al (1999), JAOT.	LPSA
NSIDC	1/8 mesh	1/8 Mesh	1/8 mesh	1/8 mesh	1/16 mesh
Cos (sza) dependence of Surface Flux	LPSA	LPSA	Briegleb-type	Briegleb-type	Briegleb-type
Terminator (Twilight polar/non-polar in SW Models)	old	Old	old	new	new
Cloud a0 coefficient	0.80	0.80	0.80	0.75	0.80
LW high temperature surface correction	No	No	Yes	Yes	Yes
LW Inversion correction	No	No	Polar regions and ps < 700mb excluded	Maximum Inversion limited to 10 K	Polar regions and ps < 700mb excluded

CERES Journal Publication Citations

For all publications whether funded by CERES or using CERES data, please include the word "CERES" in the keyword list as this will facilitate listing your publication in the CERES formal publication web-page list (http://ceres.larc.nasa.gov/docs.php).

When any paper, technical report, or book chapter has either been accepted for publication or been published, please notify the CERES group of this publication by contacting Anne Wilber at (anne.c.wilber@nasa.gov).

CERES Journal Publication Citation Values (1/1/2011)

			c1	c2	c3
Year	All References	Journal Articles	Citation	Citation	Citation
2010	71	56	49	1112	2315
2009	48	47	222	1049	2183
2008	62	61	406	995	2071
2007	39	28	229	678	1411
2006	44	40	910	523	1089
2005	49	47	1090	519	1080
2004	39	39	890	361	751
2003	51	48	1187	402	837
2002	78	69	3347	291	606
2001	50	44	1560	199	414
2000	34	32	879	173	360
1999	24	21	612	141	294
1998	20	20	1584	77	160
1997	9	9	265	52	108
1996	5	5	573	52	108
1995	1	1	17	20	42
1994	1	1	3	13	27
1993	6	6	33	0	0
Total	631	574	13856	6657	13856

Citation c1 = # of citations for papers published in that year.

Citation c2 = # of citations for papers published in all years using a specified set of categories.

Citation c3 = renormalized # of citations for papers published in all years so that the total number of citations in c3 = c1